8.   GROUND SUPPORT SERVICES

Fulfilling the TRMM requirements will require both mission-specific and institutional services provided by various GSFC elements. A number of these elements and their support services have been referred to throughout this document, but a few key elements require separate sections of their own for an adequate description. These elements are the Flight Dynamics Facility (FDF), which provides mission planning aids, orbit and attitude verification and analysis, and sensor calibration; the Software Test and Training Facility (STTF), which supports flight software anomaly troubleshooting and maintenance; the Sensor Data Processing Facility (SDPF), which provides data capture, processing, distribution, and archive; NASA Communications (Nascom) which provides data and voice circuits for command and telemetry operations; and NCC, which provides service planning and control for scheduling of the Spaceflight Tracking and Data Network (STDN). The Space Network and Ground Network/Deep Space Network, also key elements, provide support for command and telemetry communications to the spacecraft.

8.1   FLIGHT DYNAMICS FACILITY

The Flight Dynamics Facility (FDF) operates under the Flight Dynamics Division, Code 550, at GSFC, and is responsible for computing and providing orbit determination, ground-based attitude determination, TCXO center frequency measurement, attitude sensor calibration, fuel monitoring, mission analysis, and mission planning aids in support of the mission. FDF support will occur throughout all phases of the TRMM lifetime. In addition, the FDF will provide software utilities for use in the MOC.

8.1.1   Orbit Determination

By using real-time tracking data from the space network, the FDF generates definitive and predictive orbit ephemerides. The definitive orbit ephemeris is used by the science data processing facilities for tagging, processing, and interpreting scientific data collected by the TRMM instruments. The predictive orbit ephemeris is used for mission planning and scheduling functions among the FOT and science community.

The FDF updates the TRMM orbit daily with the most recent 34 hours of TDRSS tracking data. At least 10 minutes of TDRS two-way Doppler are required each orbit to achieve the definitive orbit accuracy requirement of 1 km along and across track and 100 meters radially. Each daily definitive 34-hour data arc includes a 10-hour data overlap with the previous day's solution, to allow for quality assurance and analysis.

8.1.2   Attitude Determination

The TRMM observatory attitude (Roll and Pitch) is computed on-board to a 0.4° control accuracy with respect to the horizon bisector. Attitude errors and rate information relative to the geodetic reference frame are telemetered to the ground and used as the definitive attitude solution by the TRMM ground systems. Science data processing will be based on the attitude solution computed on-board.

The FDF receives ACS telemetry data and generates a ground-computed definitive attitude solution for OBC performance and evaluation. FDF attitude computations are performed periodically to provide a validation of the onboard solution and to compute ACS sensor biases to maximize attitude performance. ACS sensor bias information is provided to the FOT for uplink to the observatory as required.

8.1.3   Planning Aids

Operations products produced by the FDF in the form of planning aids are transmitted daily, weekly, monthly, and quarterly to the MOC and the FOT. Details regarding specific FDF planning aids, their frequency of delivery, and their planned usage in the MOC are defined in the Operations Agreement for the TRMM Between the FOT and the FDF. Planning aids will be transferred to the MOC via Transmission Control Protocol/Internet Protocol (TCP/IP) over Ethernet, and to the FOT via Fax or E-mail. Operational products to be transmitted include predicted TRMM ephemerides, TRMM Extended Precision Vectors (EPVs), TDRS EPVs, COMETS EPVs, ACS system tables, Local Oscillator Frequency (LOF) reports, Predicted Site Acquisition Tables (PSATs), HGA Gimbal Angle/Range data, Solar Beta angle/Ground track data, attitude definition files, User Antenna View (UAV) files, and Solar, Lunar, and Planetary (SLP)* ephemerides. Instrument planning aids for CERES and VIRS will also be generated by FDF provided software via the GSOC utility running in the MOC. In addition, the Maneuver Planning and Maneuver Command files will be provided by the FDF for Delta-V maneuver planning. The following sections provide more details of the above mentioned planning aids.

*delivery of SLP ephemeris is still TBD

8.1.3.1   Predicted TRMM Ephemerides

The predicted TRMM ephemeris data are used for spacecraft maneuver constraint checking and HGA modeling by the MOC system. TRMM ephemeris data are also used by certain mission operations and analysis software programs described in Section 8.1.5. The file contains predicted orbital elements and geocentric inertial (GCI) position and velocity components in the True-of-Date J2000 coordinate frame. These predicted components are at a specified time interval (one minute centers) and span a 9-day period, beginning at 0000z of the previous day. The first 34 hours consist of definitive data while the remaining data is predictive ephemeris data.

8.1.3.2   TRMM, TDRS, and COMETS Extended Precision Vectors

EPVs are used by the onboard orbit propagation algorithm within the ACS microprocessor. They are also used to facilitate an adequate communication link with the TDRSS and COMETS via the HGA. FDF provides EPVs for TRMM, up to six TDRSs, and COMETS.

During normal operations, FDF provides a daily TRMM EPV file containing EPVs at one hour intervals, beginning at 12:00z of the current day and spanning 48 hours. Separate TDRS and COMETS EPV files are also provided, containing EPVs at two hour intervals. These ASCII-formatted files are transmitted to the MOC every 1 month for TDRS and weekly for COMETS. The TDRS files contain 5 weeks worth while the COMETS file contains 8 days worth of EPV data. Upon receipt, each EPV is validated and formatted for uplink by the MOC system. EPVs selected for uplink must be transmitted to the spacecraft before their associated epoch times.

8.1.3.2.1   OBC Validation Reports

FDF will trend the OBC propagation of the uplinked TRMM and TDRS EPVs. A weekly report will be provided to the FOT.

8.1.3.3 ACS System Tables

The ACS system tables contain dynamic data that the flight code uses during the life of the mission. As required, FDF will provide updated values for these tables. ACS system tables include several attitude sensor calibration tables including the ESA calibration table and gyro biases, in addition to solar and lunar ephemerides which are not updated by FDF.

Since a reference Sun position is used in the ACS processing algorithm, a solar ephemeris table is utilized, providing 10 arcsec/year accuracy. A lunar ephemeris table is also used. Planetary positions are not modeled by the ACS software. ESA inputs will be direct from the FDF and will be formatted by the MOC. In addition, FDF provides other ACS system table updates, via the Onboard Computer Software Tools (OST) workstation, to the MOC on an as-needed basis.

8.1.3.4 Local Oscillator Frequency Reports

LOF reports contain Transponder oscillator frequency information for each scheduled non-coherent tracking event. These ASCII-formatted files include event start/stop times, Transponder identification, predicted/observed transmission frequencies, and frequency offset for each tracking event. LOF reports also contain summary statistics for each Transponder, including average frequency values, average offsets, and offset standard deviations spanning the entire reporting period. These reports can be used to verify computed frequency offsets using the Statistic Phase Error (SPE) parameters found in Transponder telemetry. During normal operations, LOF reports are transmitted monthly to the FOT.

The FOT will trend frequency offsets throughout the life of the mission, correcting center frequencies when necessary. This is done by either adjusting (via command) the spacecraft Center Frequency Offset (CFO) to its nominal value or by updating the reference center frequency in TRMM's Network Control Center (NCC) configuration codes. The SN requires that user spacecraft stay within ±1500 Hz of the frequency listed in the configuration codes. Section 4.5 describes Transponder frequency maintenance in more detail.

8.1.3.5 Predicted Site Acquisition Tables

PSATs contain predictive information concerning orbital events and view periods for the Space Network (SN), Ground Network (GN), and Deep Space Network (DSN). PSATs are used both for the scheduling of command activities about orbital events by the MOC stored command management software and for SN scheduling by the User Planning System (UPS). Orbital events listed in PSATs include the following:

      a.   ascending/descending node crossings
      b.   South Atlantic Anomaly (SAA) entrance/exit
      c.   sunrise/sunset

    d.   Sun and multi-path RF interference regions

    e.   TDRS, GN, and DSN view periods

PSATs are in American Standard Code for Information Interchange (ASCII) format, with daily short term PSAT files spanning a 1 week period with updated burn plans factored in. Long term weekly PSAT files span a 4-week period with predicted burns factored in. PSAT files start at the first ascending node after 00:00z of the day following the day of delivery.

8.1.3.6   **HGA Gimbal Angle/Range Data Files**

The HGA Gimbal angle file is used to support HGA pointing to TDRS. The file also contains x-y antenna position parameters as well as TRMM - TDRS - White Sands range data to be used for spacecraft clock correlation. These files will be delivered to the MOC daily and weekly.

8.1.3.7 Solar Beta Angle/Ground Track Data Files

The Solar Beta Angle file, which includes ground track (latitude, longitude, and altitude), is used to plan and schedule the 180° yaw maneuvers in both the long and short terms. It will also be used to schedule Biaxial operations for the CERES instrument. In addition, the ground track is used to correlate spacecraft anomalies to geographical locations. These files are sent to the MOC daily, weekly, and quarterly and contain records at 1 minute, 3 minute, and 12 hour intervals, respectively.

8.1.3.8 Attitude Definition Files

An attitude definition file specifies which telemetry mnemonics are to be collected by the MOC system during the real-time pass. The MOC has the capability to transmit these attitude telemetry files to FDF each real-time pass or to record the real-time data for later transmission to FDF. Another option for transmission of the attitude telemetry files to FDF includes the capability in the MOC to provide attitude subset files from the SDPF provided Level-0 file. Attitude definition files are transmitted from FDF to the MOC on an as-needed basis using TCP/IP.

8.1.3.9 TRMM/COMETS User Antenna View (UAV) Files

UAV files are used by the User Planning System (UPS) for the scheduling of TDRS real-time events. These ASCII files contain start/stop times of when various TDRS services are possible given the geometry of the orbit and expected attitude of TRMM. Short term UAV files (spanning one week) are sent daily to the MOC and are used for verification of scheduled events (verify still in view after Delta-V). Throughout the mission, long term files (spanning 4 weeks) are sent to the MOC weekly and are used for TDRS scheduling via the UPS. Special attitude dependent UAV files will be delivered upon special request for the 90° PR Antenna Pattern Measurement and the CERES Deep Space Calibration. The FDF will also deliver COMETS UAV files daily (spanning 7 days) and weekly (spanning 4 weeks) during the COMETS experiment phase.

8.1.3.10 Solar, Lunar, and Planetary Ephemerides

SLP ephemeris data are used by the GSOC and RTADS utilities. GSOC will use the SLP data in producing CERES and VIRS planning aid files and Earth sensor interference files, as defined in Section 8.1.5.3. RTADS will use the SLP data to provide real-time attitude displays. SLP ephemeris data will span a 20 year period and will be delivered to the MOC monthly.

8.1.3.11 Time Conversion Coefficients Files

The Time Conversion Coefficients Files, which are inputs to the GSOC utility, are used for leap second correction determination. They span a 20 year period will be delivered to the MOC monthly.

8.1.3.12   **Delta-V Maneuver Files**

The FDF will provide a Maneuver Planning file every week. This file will contain day and estimated time for the orbit maneuver burns, spacecraft orientation, and the estimated duration of each burn. The Maneuver Planning file will be used for long term planning of Delta-V operations with other spacecraft and instrument operations. It will span 5 weeks and will be updated weekly.

A Maneuver Command file will be provided for each maneuver at least 24 hours before the scheduled maneuver burn time. This file will contain information necessary for the planned Delta-V, including the maneuver start time, duration, thrusters to be used, spacecraft orientation, predicted geodetic altitude and eccentricity, predicted delta-velocity, predicted delta-semi major axis, estimated fuel used for the maneuver, estimated fuel used to date, fuel remaining, and tank temperatures and pressures. It will also contain a post-maneuver EPV. The information in the maneuver command file will be used as input for the Delta-V maneuver command loads. More information regarding these two files can be found in Section 7.

8.1.4   **FDF Fuel Monitoring/ Maneuver Trending**

Throughout the mission, FDF will track the estimated amount of fuel on-board the spacecraft and perform trending of each Delta-V maneuver. The FOT will provide FDF with RCS temperature and pressure information that FDF will use to gauge RCS performance and fuel consumption. The information will cover one orbit worth of data for an orbit about 24 hours before the maneuver. In addition, subsequent to each maneuver FDF will use the burn duration times for each thruster to determine the estimated amount of fuel used for that maneuver. The amount used will be subtracted from the estimated current amount to keep a running total of remaining fuel onboard. FDF will use this information to ultimately determine when the end of life ocean disposal will occur. Section 7.1.1.4 gives additional details regarding maneuver trending and performance.

8.1.5   **FDF Software Utilities**

Certain mission operations and analysis software utilities, supplied by FDF, are resident in the MOC. These include the Real-Time Attitude Determination System (RTADS), Heads-Up Display (HUD), and Guide Star Prediction and Occultation (GSOC) Utility.

8.1.5.1   **Real-Time Attitude Determination System**

RTADS is a non-interactive real-time TPOCC workstation-based program that determines and tabularly displays spacecraft attitude information. Computed attitude data using the Filter Quaternion Estimator (FilterQUEST) and Extended Kalman Filter (EKF) algorithms are listed with the spacecraft-computed attitude (obtained from telemetry). Various combinations of Digital Sun Sensors (DSSs), Coarse Sun Sensors (CSSs), Three-Axis Magnetometers (TAMs), and gyro (analog or digital) data can be used in these algorithms. Gyro biases and sensor residuals computed by the EKF can be displayed to show solution accuracy.

Using TRMM and TDRS ephemerides, 3 component rotation vector between the spacecraft-computed attitude and both RTADS attitudes (i.e., FilterQUEST and EKF) can be displayed. The update rate of the RTADS display is 4 seconds. Optionally, certain RTADS output parameters can be written to the TPOCC data server to be accessed by other MOC utilities, such as SpaceCam. Those items written to the data server will also be available for trending in GTAS.

Datasets required by RTADS include: TRMM and SLP ephemerides and the timing coefficients file. In addition, a parameter file containing processing/display options and sensor calibrations/conversion coefficients, along with spacecraft telemetry from the TPOCC data server or sequential attitude file is required.

8.1.5.2 Heads-Up Display

The HUD is a non-interactive real-time TPOCC workstation-based program that graphically displays spacecraft sensor, actuator, and attitude data obtained from telemetry. The HUD has the capability to display sensor and actuator data from the DSSs, TAMs, reaction wheels, gyros (analog or digital), CSSs, ESA, and magnetic torquer bars (MTB) individually or concurrently.

Spacecraft-computed attitude data can also be displayed. In addition, a difference between the observed and computed information of roll, pitch, and yaw angles between the spacecraft-computed attitude and the RTADS EKF attitude (Section 8.1.4.1) can be displayed. The update rate of the HUD display is 4 seconds.

Selected parameters are limit-checked (i.e., within minimum, maximum, and operational limits) and displayed in a color-coded format. Datasets required by the HUD include: a parameter file containing processing/display options and sensor calibration/conversion coefficients, and spacecraft telemetry from the TPOCC data server or sequential attitude files (Section 11.1.2.2). HUD is activated and deactivated via a TSTOL directive. The HUD display is brought up by invoking the Generic Spacecraft Analyst Assistant (GenSAA) from the MOC menu.

8.1.5.3   Guide Star Prediction and Occultation Program

The XTE-based GSOC is an interactive UNIX/POSIX-based TPOCC workstation-based utility, updated for TRMM usage, that will be used to provide Sun/Moon interference files, and CERES and VIRS planning aids. Residing in the MOC, the GSOC utility will be utilized by the FOT on an as needed basis to produce specific planning aids.

The Sun/Moon interference file will be generated as needed for resolution of ESA anomalies. GSOC will also produce predicted Azimuth/Elevation angles for the CERES instrument. This planning aid will be used to determine times for the CERES Solar calibrations and will also be used for solar avoidance commanding when CERES is in the Biaxial mode. VIRS planning aids, which include when the Moon is in the Space port FOV and when the Sun is in the FOV of the calibration port, will also be generated via the GSOC utility. These will be used for verification of lunar presence in the space port and for planning Solar calibrations for the VIRS instrument, respectively. The VIRS planning aids will be transferred to the VIRS instrument scientist via the SOCC for VIRS planning.

Datasets required by GSOC include TRMM and SLP ephemerides and the timing coefficients file. GSOC can be executed interactively or in batch mode via a MOC menu, or autonomously upon prior direction.

8.2   SOFTWARE TEST AND TRAINING FACILITY

The Software Test and Training Facility (STTF), operated by Code 512, the Flight Software Systems Branch (FSSB), provides on-orbit flight software maintenance support for TRMM. This includes the development and testing of spacecraft flight software changes using a high fidelity spacecraft dynamic simulator and a number of lesser fidelity subsystem simulators operating in conjunction with an engineering model of the spacecraft C&DH subsystem. In addition to supporting flight software testing the STTF will also be used to support FOT training from the MOC.

8.2.1   **Flight Software Maintenance and Testing**

The primary FSSB-MOC interface will be in the area of flight software table and memory updates to on-board processors. The FSSB will be responsible for the maintenance of the following processor memory:

- a.   Spacecraft processors
- b.   ACS processors (in conjunction with Code 700 representatives)
- c.   ACE processors (in conjunction with Code 700 representatives)
- d.   PSIB

Certain FDS tables, which are updated routinely, are FOT-controlled and do not require coordination with the FSSB. These include ATS buffers, RTSs, and Earth Sensor Assembly (ESA) calibration data. Most tables and processor memory are configured areas of the FDS and updates require coordination among the FOT, FSSB, and MD. The flight software configuration control board, chaired by the FSSB, is the responsible agency for coordinating and approving all changes to onboard memory.

Approved flight software changes are implemented by table and memory updates. Load data are provided by the FSSB, to the FOT, via the OST workstation. Upon receipt of these data, the MOC automatically generates a load. The FOT will uplink this load, typically using FSSB-provided procedures and verify the changes to flight software through FSSB-provided criteria. Normally, all loads and procedures are first validated against the STTF simulator.

The FOT, in turn, will provide the MOC managed Ground Reference Images (GRIs) for uplinked loads to the STTF via the OST. Dump packet files are also provided on an as-requested basis. In support of anomaly investigation, the FSSB may request additional data from the FOT. This may include table and memory dumps, interpreted dump reports, and dwell data.

8.2.2   **Onboard Computer Support Tools Workstation**

The OST workstation provides an interface between the MOC and FSSB for the transmission of memory and table images, as well as analysis tools for troubleshooting flight software anomalies. The OST is resident in the MOC and connected to the MOC LAN. The interface to the FSSB will be by floppy disk. The OST will be operated by FSSB personnel.

8.3   **SENSOR DATA PROCESSING FACILITY**

The Sensor Data Processing Facility (SDPF), is responsible for real-time and playback data collection, data accountability, Quicklook and Level-0 data processing, data distribution, and archive. The SDPF includes the Data Capture Facility (DCF), the Packet Processor (Pacor) II, and the Data Distribution Facility (DDF). Figure 8.3-1 illustrates the SDPF, its components, and their data flows.

The SDPF receives TRMM's real-time and playback telemetry from the White Sands Complex (WSC) through Nascom. SDPF processes the telemetry data and provides Quicklook and Level-0 data sets to the TRMM users, which include the MOC, TSDIS SDOC, LaRC, MSFC, and NASDA. In addition to recording raw data, SDPF performs error detection and correction, merges, time-orders, and sends data to users. SDPF also provides data quality accounting at the packet level. Data at the Nascom block data level are stored locally for 30 days and off-site for two years. Level-0 files are also stored on-line for 5 days. In addition, Level-0 files will be routinely stored on CD-ROM and transferred to the MOC for long-term storage. SDPF will also be responsible for distributing the ephemeris files from FDF to the user facilities.
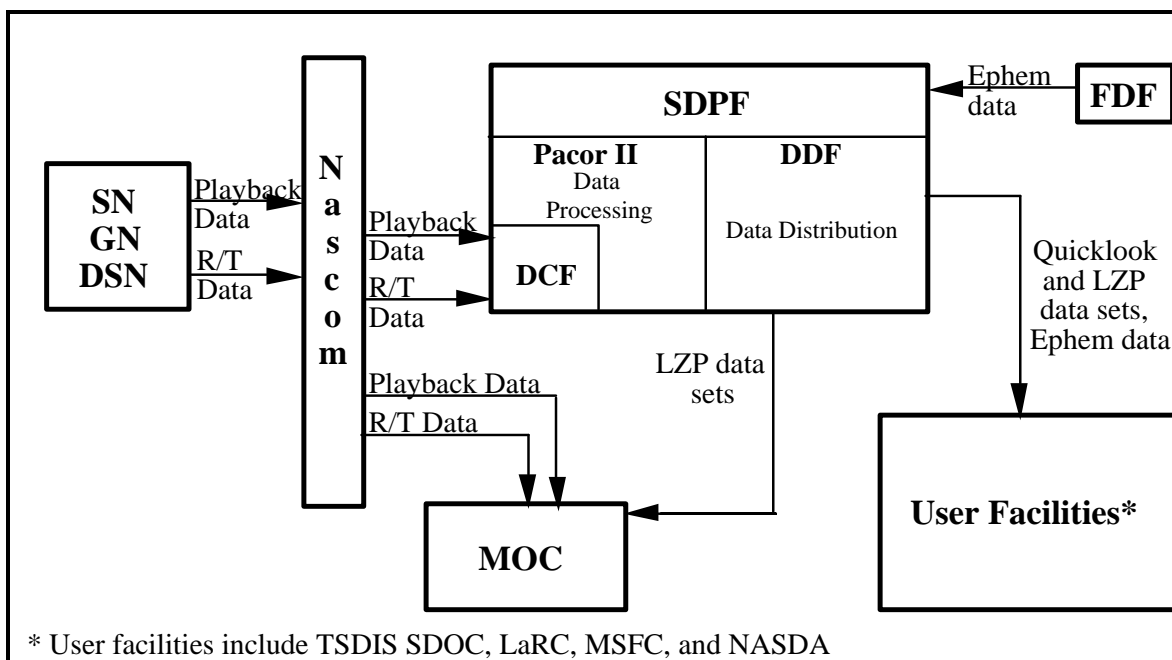

Figure 8.3-1 Sensor Data Processing Facility (SDPF) Interface Diagram

8.3.1   Data Verification and Accountability

Pacor II accepts real-time and on-board recorder playback data from the TRMM observatory via Nascom. After removing data from 4800-bit Nascom blocks, the Pacor II system does the following:

       a.   recovers the original CCSDS telemetry packets.
       b.   removes fill packets.
       c.   appends quality information.
       d.   stores the packets.
       e.   groups the stored packets into data sets.
       f.   transmits the data sets to the DDF for forwarding to customers.

Quality information required for Pacor consists of the total number of Nascom blocks received, total number of Nascom blocks with errors, total number of VCDUs received, total number of VCDUs received in each VC, percentage of VCDUs with R-S error, percentage of VCDUs with sequence errors, and the total number of packets per APID received during the session.

8.3.2   Level-0 Processed and Quicklook Data

Level-0 data are used in the MOC for long-term trend and performance analysis and for archiving, The files will be routinely transferred, with CD-ROM available as a back-up. A workstation in the MOC decommutates the Level-0 data and builds telemetry subset files for use by the Generic Trend Analysis System (GTAS). In addition, the instrument facilities use the Level-0 files for instrument trending and analysis, science data analysis, and for higher level science data processing.

Quicklook data sets contain playback data (as defined be each user) received during a single TDRS contact. Quicklook files are sorted by APID and are time ordered. Quicklook data are used on a regular basis and during special calibrations, anomaly investigations, and to recover missing data in a timely manner.

Each instrument facility will receive three scheduled Quicklooks per day. Pacor will process three recorder playbacks per day as a file of packets, and forward the Quicklooks to the Data Distribution Facility (DDF) to be transferred to the remote instrument sites. All five instruments will not necessarily receive Quicklook data from the same three playbacks.

Once Level-0 and Quicklook data sets are processed by SDPF, they are sent to the DDF. The DDF distributes Level-0 data sets to the TSDIS SDOC, MOC, LaRC DAAC, MSFC LIS SCF, and the NASA/NASDA Interface Point within 24 hours of receipt of the last packet in the data set. Level-0 processed data contains all telemetry received in a 24-hour period, sorted by APID and time ordered. Redundant packets are removed and missing packets are identified. Quicklook data sets are processed on a scheduled basis, 3 times per day, and are transmitted within 2 hours of data receipt to the TSDIS SDOC, LaRC DAAC, MSFC LIS SCF, and NASA/NASDA Interface Point.

8.4   NASCOM

NASA Communications (Nascom) will ensure that there are data and voice circuits sufficient to conduct telemetry and command operations for TRMM. A TRMM real-time support schedule will be sent from NCC weekly and then again daily prior to the active event day. It will include all TDRSS events for that day derived from UPS-generated Schedule Add Request input consisting of selected configuration codes. From this schedule, Nascom ensures the availability of necessary data and voice lines. Nominally, data will be routed to the MOC and SDPF per Interface Channel ID assignments found in the configuration codes. Nascom is tasked to provide data links destined for the TRMM MOC. The data is transferred along exclusive lines into a Local TPOCC Switch (LTS) at the MOC where the telemetry is routed to the Front End Processor (FEP) of the receiving string. A forward link, which provides command capability, is also available. Note that an alternate arrangement allows data into the Special Operations and Test Area (SOTA) and either simultaneously (Launch support) as data is routed to the MOC, or exclusively (testing) depending on the nature of the support requirement. In this configuration,

Nascom is tasked to provide data links destined for the Central TPOCC Switch (CTS) located in Building 14.

Nascom has provided four data lines for TRMM. Three will be used for SN events and consist of two duplex circuit-switched lines supporting an I- or Q-Channel at a 2 Mbps incoming rate along with 56 Kbps outgoing. This is sufficient for the SN command rate of 1 Kbps. (Nominally commanding will occur via the I-Channel). The third is a duplex message-switched line which will handle SN non-real-time traffic such as Ground Control Message Request (GCMR) transmissions and Operational Data Message (ODM) reception at a 56 Kbps rate both ways. These data will be multiplexed into the I-Channel telemetry stream. The FEP will recognize the different data and store each in an appropriate directory and perform applicable accounting functions.

The fourth data line is also a duplex message-switched type to be used for DSN/GN/WFF/AGO (ground) supports. It is rated for a 224 Kbps capability both incoming and outgoing. This incoming rate will increase the time required to perform a recorder playback, but this will only be attempted in an Emergency situation.

Voice communication is provided in the form of Switching, Conferencing, and Monitoring Arrangement (SCAMA) and Closed Conference Loop (CCL) lines. SCAMA lines place the FOT in direct communication with the NCC for nominal SN operations as well as with JPL or the GN for contingency operations. FDF and SDPF are also included on the SCAMA. The CCL is a more private voice loop between two users. These lines exists between the MOC-SDPF, MOC-TSDIS SOCC, and MOC-FDF to name a few.

8.5   SPACE NETWORK

The Space Network (SN) consists of the Tracking and Data Relay Satellite System, which includes the operational TDRSs and the White Sands Complex (WSC). TDRS is controlled at the WSC in White Sands, New Mexico. The WSC controls each TDRS and transmits user data between the TDRS and the ground user, via the Data Interface System. WSC performs TRMM signal processing and data handling, including range and range rate operations, Doppler frequency compensation, signal modulation encoding, and Viterbi decoding.

The Space Network will provide the TDRSS resources necessary to meet the real-time support requirements of the mission. Nominally, the FOT does not interface with White Sands personnel directly. Instead, the Network Control Center (NCC) is used to schedule TDRS supports, as detailed in section 8.7. Additional details of the SN's role with the TRMM can be found in sections 4.5, 6.6, and 7.3.

8.6   GROUND NETWORK/DEEP SPACE NETWORK

Except for periodic proficiency supports (twice per month with each station), ground support operations with the GN/DSN/WFF/AGO (hence forth noted as GN/DSN) will be conducted only as a result of a contingency or emergency condition. This contingency support would be used to re-establish communications with the spacecraft to determine its health and safety status. In this situation, science data collection (to the ground) would not be attempted.

Station support, along with data rate information, is described in table 8.6-1. For DSN supports, data (both telemetry and command) must be routed through the Jet Propulsion Laboratory (JPL) which controls DSN operations. In addition, all sites will pass the real-time data to the MOC and SDPF in a throughput mode. If a recorder playback is attempted, the playback data will be recorded on-site by the station. A post-pass playback to the SDPF and the MOC will be required in order to receive the data.

Station	Acronym	Network	Data Rate	Data Type	Strip and Ship
Merrit Island	MIL	GN	1 Kbps	real-time	N/A
Bermuda	BDA	GN	1 Kbps	real-time	N/A
Goldstone	D16/17	DSN	1024 Kbps	real-time & playback	real-time
Canberra	D46	DSN	1024 Kbps	real-time & playback	real-time
Madrid	D66	DSN	1024 Kbps	real-time & playback	real-time
Wallops Flight Facility	WFF		1024 Kbps	real-time & playback	real-time
Santiago	AGO		1024 Kbps	real-time & playback	real-time

Table 8.6-1 Station Support Information

The entire data downlink will be recorded at the GN/DSN sites although housekeeping data (VC0) will be provided to the MOC in real-time. Recorder playback data will be transferred as a non-real-time, post-pass playback (PP/PB) mode at a variable transmission rate not to exceed the capacity of the 1024 Kbps JPL-GSFC link and 128 Kbps for AGO (Note: The actual maximum telemetry data rate between AGO and GSFC is approximately 48.2 Kbps due to Nascom overhead and voice bandwidth allocations. For DSN, the post-pass playback will be scheduled at the maximum bandwidth availabl, as the 1024 Kbps line is also used to support all other GSFC missions.)   Additional real-time support operations will take precedence over this PP/PB, reducing or possibly halting (temporarily) the ongoing playback activity from JPL.

As mentioned above, GN/DSN supports will be used for proficiency training as well as for emergency/contingency situations. Each station will be scheduled twice per month in order to familiarize the FOT with GN/DSN operations. These training opportunities will also allow the ground sites to become familiar with TRMM operations.

8.7   NETWORK CONTROL CENTER

The Network Control Center (NCC) will provide service planning and control for scheduling of the Spaceflight Tracking and Data Network (STDN). STDN includes the SN, GN, and DSN. The NCC will assist in pre-mission planning which includes data base submission (configuration codes, spacecraft characteristics, and prototype events) and participation in certain spacecraft tests.

All scheduling for TDRS supports will be done by the NCC via remote inputs to the UPS, from a MOC resident workstation. NCC operators will schedule all TDRS supports for all users according to priority lists of events and spacecraft. NCC operators will attempt to resolve all

conflicts in TDRS schedules via direct communications with the specific spacecraft's Mission Planner. GN and DSN supports will be scheduled with NCC via phone and fax communications.

Being the link between the White Sands Complex (WSC) and the different MOCs, the NCC forwards active TDRS schedules to WSC to allow preparation for spacecraft supports. The NCC also participates in real-time supports, receiving performance messages from WSC, forwarding Ground Control Message Requests (GCMRs) from the MOC to WSC, and assisting in support anomalies during real-time events.